REMARKS

In the Office Action mailed on March 28, 2003, the Examiner rejected claims 24 – 31. With this Amendment, Applicant has amended claims 24, 26, and 30 and added claims 32 – 37. The application now includes claims 24 – 37.

Applicant has enclosed a Petition for Three-Months Extension of Time together with a Credit Card Payment Form for payment of the extension.

The Examiner stated that none of the certified copies of the priority documents have been received. This application is a PCT application which properly entered the U.S. National Stage. Applicant believes that the priority documents were sent by the PCT office in accordance with the request made by the Applicant. Correction is respectfully requested.

REJECTION OF CLAIMS UNDER 35 U.S.C. § 112

The Examiner rejected claim 26 under 35 U.S.C. 112, second paragraph, as being dependent on a canceled claim. With this Amendment, Applicant has amended claim 26 in accordance with the Examiner's instructions.

REJECTION OF CLAIMS UNDER 35 U.S.C. § 102

Claim 30

The Examiner rejected claim 30 under 35 U.S.C. § 102(b) as being anticipated by the Haas et al patent in light of the Olsen patent. While the Examiner has stated that the rejection of claims is under the Olsen patent, he uses the Conrad patent in the discussion. Applicant will assume that he means the Conrad patent and discuss accordingly.

As background for the Examiner, a plasma is a collection of charged and neutral particles consisting of electrons, ions and neutral molecules. The ions may be either atomic or molecular fragments known as free radicals. Plasmas are generally categorized into nonthermal and thermal plasmas. If an electric field is applied to a plasma of low degree of ionization, the charged particles, especially the lighter electrons, will be energized and the bulk of the massive ions will be unaffected. Because the average electron energy or temperature is much higher than that of the bulk gas molecules, the plasma is referred to as nonthermal, nonequilibrium or simply

a cold plasma. In a thermal plasma, sufficient energy is supplied such that the electrons and ions are at the same temperature. Since the electrons and ions are in thermal equilibrium, such plasmas are also known as equilibrium plasmas. The present invention is concerned with the processing of a hydrogen sulfide containing gas stream in a nonthermal plasma.

The Haas et al patent merely describes a method for the decomposition of hydrogen sulfide into hydrogen and sulfur when exposed to a silent electrical discharge. An inert diluent gas such as argon, helium, or nitrogen is utilized together with polychlorotrifluoroethylene oil. These additives assist in obtaining higher H_2S conversions. In addition, the feed H_2S gas is introduced into the silent discharge reactor at a temperature between –40°C and 61°C. The Haas et al patent further stipulates that the cooler the temperature, the greater the hydrogen sulfide conversion and the rate of decomposition. The preferred H_2S concentration range is from about 0.25% to 10%.

There are important limitations that make the Haas et al process economically and technologically unviable and unsuitable for integration with a hydrogen sulfide removal process such as that proposed in the present invention. The first limitation emanates from the fact that hydrogen sulfide is a very corrosive gas. The lack of metals that could resist H_2S corrosion at a wide range of concentration and temperature has hampered efforts in exploiting nonthermal plasma reactors as means for processing H_2S. Second, hydrogen sulfide is a toxic gas and hence processing the gas in a glass reactor raises safety concerns. Third, in the temperature range of between –40°C and 61°C proposed, sulfur would be released in the solid state and deposit in the walls of the reaction vessel rendering the reactor inoperable. Fourth, the product stream of the silent discharge reactor consists of hydrogen and hydrogen sulfide since only 97% of the feed H_2S is converted. For the process to be commercially viable, the unreacted hydrogen sulfide remaining in the product gas must be removed.

The Conrad patent adds nothing to the Haas et al patent and is merely a representative example of a corona discharge of the silent discharge (dielectric barrier discharge) type. The present invention, as claimed, claims a method for converting H_2S in a natural gas stream to elemental sulfur and hydrogen with the method comprising providing a nonthermal plasma corona reactor, introducing the natural gas stream into the nonthermal plasma corona reactor, and

removing contaminants from the natural gas stream and converting the H_2S in the natural gas stream to elemental sulfur and hydrogen at a predetermined temperature in a single operation. As set forth above, the Haas et al patent and the Conrad patent fails to describe such a method.

Therefore, since neither the Haas et al patent nor the Conrad patent, together or separate, either teach or suggest the invention as claimed in the present application, it is respectfully requested that the rejection of claim 30 under 35 U.S.C. § 102(b) be withdrawn and that claim 30 be held allowable.

Claims 24, 25, and 31

The Examiner rejected claims 24, 25, and 31 under 35 U.S.C. § 102(b) as anticipated by the Haas et al patent in light of the Conrad patent.

Applicant has described in detail above the reasons that the Haas et al patent and the Conrad patent neither teach nor suggest the present invention as claimed in claim 30. Claim 24 has been amended to claim an apparatus for converting H_2S in a natural gas stream to elemental sulfur and hydrogen in a single operation with the apparatus comprising a device for removing contaminants from the natural gas stream and conversion means for receiving the natural gas stream and for converting H_2S in the natural gas stream to elemental sulfur and hydrogen at a predetermined temperature.

Therefore, since neither the Haas et al patent nor the Conrad patent, together or separate, either teach or suggest the invention as claimed in the present application, it is respectfully requested that the rejection of claims 24, 25, and 31 under 35 U.S.C. § 102(b) be withdrawn and that claims 24, 25, and 31 be held allowable.

REJECTION OF CLAIMS UNDER 35 U.S.C. § 103

Claims 24, 25, and 31

The Examiner rejected claims 24, 25, and 31 under 35 U.S.C. § 103(a) as obvious over the Haas et al patent in light of the Conrad patent.

Applicant has described in detail above the reasons why claims 24, 25, and 31 are not anticipated by the Haas et al patent and the Conrad patent. Therefore, since neither the Haas et al

patent nor the Conrad patent, together or separate, either teach or suggest the invention as claimed in the present application, it is respectfully requested that the rejection of claims 24, 25, and 31 under 35 U.S.C. § 103(a) be withdrawn and that claims 24, 25, and 31 be held allowable.

Claims 26 – 29

The Examiner rejected claims 26 - 29 under 35 U.S.C. § 103(a) as obvious over the Haas et al patent in light of the Conrad patent, and further in view of CA 675292A (Milton) and Applicant's admission.

The Milton patent adds nothing to the Haas et al patent and the Conrad patent to render the claims of the present application obvious. The Milton patent merely describes a process for removal of hydrogen sulfide and moisture from natural gas using a fixed bed of molecular sieves. The Milton patent describes a two-fixed bed adsorption-desorption method where a sour natural gas stream is continuously stripped of moisture, hydrogen sulfide, and mercaptans by contacting with a zeolitic molecular sieve bed having molecular sieve material with an apparent pore size of at least 5 Angstroms units. While the first molecular sieve fixed bed is in the desorption stroke, a second molecular sieve fixed bed undergoes desorption by passing a heated fluid (300 – 600 °F), preferably oil, in a heat exchange coil immersed in the bed. Simultaneously, heated purge gas consisting of a slip stream of the impurity-free natural gas flows in direct contact with the molecular sieve bed, sweeping out the moisture and hydrogen sulfide impurities until the desorbed bed reaches a temperature of at least 300 °F. The bed is recooled by passing a portion of the impurity-depleted natural gas product stream.

Unfortunately, the process described by the Milton patent has serious limitations arising from the use of a fixed bed as a means for contacting sour natural gas with the adsorbent. The first drawback is that during the desorption stroke the heated fluid transfers heat through the conduit walls into the sieve bed of stationary solids. Because of the inefficient heat transfer between the walls of the embedded coils and the bed of molecular sieve solids, large heat transfer surface areas would be needed requiring large vessels and higher capital costs. Thus, inefficient heat exchange limits scale up of the adsorption-desorption vessels for commercial application. Secondly, low heat transfer rates would mean longer processing times. Thirdly, inefficient heat

transfer gives rise to poor temperature distribution in the bed which causes temperature gradients, thus creating serious temperature control problems, and in extreme cases local hot spots may develop that could lead to overheating of the molecular sieve particles. Overheated particles may either sinter, causing the vessel to plug or if the hot spot temperature exceeds 600 °F the molecular sieves would be damaged and lose their adsorptive capacity. Fourthly, the Milton patent does not address the issue of sulfur pollution caused by discharging adsorbed hydrogen sulfide and mercaptans during the desorption stroke. Removal of sulfur from a fluid stream must meet the sulfur emission requirements set by various air pollution and control authorities. Finally, the system is inherently energy inefficient since the heated fluids for direct and indirect heat exchange would not be able to transfer much heat to the bed of molecular sieves due the limitations in heat transfer rates discussed above. These limitations render the commercial processing of natural gas using the method described by the Milton patent unviable.

Therefore, since neither the Haas et al patent, the Conrad patent, nor the Milton patent, together or separate, either teach or suggest the invention as claimed in the present application, it is respectfully requested that the rejection of claims 26 – 29 under 35 U.S.C. § 103(a) be withdrawn and that claims 26 – 29 be held allowable.

CONCLUSION

Before the present invention, there was a need for a nonthermal plasma reactor that efficiently and economically decomposes hydrogen sulfide into hydrogen and sulfur and does not have the disadvantages of the references cited and discussed above. Conventional processes for removal of hydrogen sulfide from a gaseous stream did not offer subsequent processing of hydrogen sulfide to recover both hydrogen and sulfur as valuable products in a single operation. Processes for the decomposition of hydrogen sulfide into hydrogen and sulfur did not provide the means for removing hydrogen sulfide in a gaseous stream as a single operation.

The present invention provides an integrated process for removal of hydrogen sulfide from a gaseous stream and the subsequent processing to recover hydrogen and sulfur as commercially valuable products in a single operation. Such a claimed process offers a compact and economically viable process that could have applications not only in natural gas processing

but also in oil refineries, coal gasifiers and many other industrial gaseous stream that contain H2S as a waste product.

In addition, the present invention provides an improved fluidized bed adsorption process capable of removing hydrogen sulfide from a gaseous stream and having the capacity to reduce attrition of the adsorbing bed material.

Furthermore, the present invention provides a process for decomposition of hydrogen sulfide in a pulsed corona plasma reactor that is made of materials that can resist hydrogen sulfide corrosion in a wide range of commercially useful concentrations and operating temperatures having the capability of recovering hydrogen and sulfur as commercially valuable products.

Further yet, the present invention provides an integrated process for removal of hydrogen sulfide from a gaseous stream and the subsequent processing to recover hydrogen and sulfur as commercially valuable products in a single operation.

Applicant believes that the present application is in condition for allowance. Reconsideration and allowance of the claims is respectfully requested.

Respectfully submitted,

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